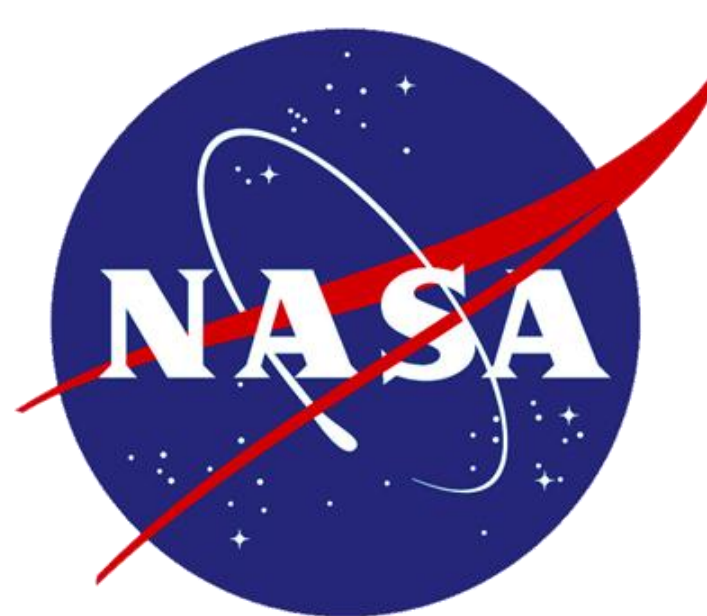




Development of a High Resolution Weather Forecast Model for Mesoamerica Using the NASA Ames Code I Private Cloud Computing Environment

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SPoRT-SERVIR Collaboration

Two projects at NASA Marshall Space Flight Center have collaborated to develop a high resolution weather forecast model for Mesoamerica:



The NASA Short-term Prediction Research and Transition (SPoRT) Center, which integrates unique NASA satellite and weather forecast modeling capabilities into the operational weather forecasting community.



NASA's SERVIR Program, which integrates satellite observations, ground-based data, and forecast models to improve disaster response in Central America, the Caribbean, Africa, and the Himalayas.

Why are cloud resources important?

- Cloud computing projects employ hardware provided through “Infrastructure as a Service”
- Reduced cost and deployment time for international partners who do not have access to high performance computing infrastructure
- Easier transition the capability to end users through use of virtual machines and images replicating the original modeling configuration.

Weather Forecasting Application

- We established a run of the Weather Research and Forecasting (WRF) Environmental Modeling System (WRF-EMS) within NASA Ames Code I private cloud computing environment.
- Each day, 48-hour forecasts are generated over three domains serving Mesoamerica:
- 12-km resolution Caribbean
- 4-km resolution Central America
- 4-km resolution Dominican Republic
- Forecasts were generated each day, with rare interruption, beginning 1 May 2012 and continue to be produced.
- Long-term model runs for given seasons provide an opportunity to perform model validation studies – to determine errors and identify ways to improve the forecasts.
- Data to be provided via the SERVIR GIS portal.

Real-Time Weather Forecasts for Central America

Currently, daily forecasts are generated for the three domains in Figure 1, based upon input boundary conditions from the NOAA Global Forecast System (GFS) model in three-hourly increments.



Figure 1. Current configuration of WRF-EMS domains in support of SERVIR interests in Central America. Resolution refers to the horizontal grid spacing in the X and Y directions.

Cloud Computing Configuration

- Daily forecasts are generated in the cloud by storing the necessary data and code on a single server (NFS) that is shared among three compute nodes.
- Once the forecasts are complete, final output data is pushed to NASA MSFC via FTP for additional post-processing.

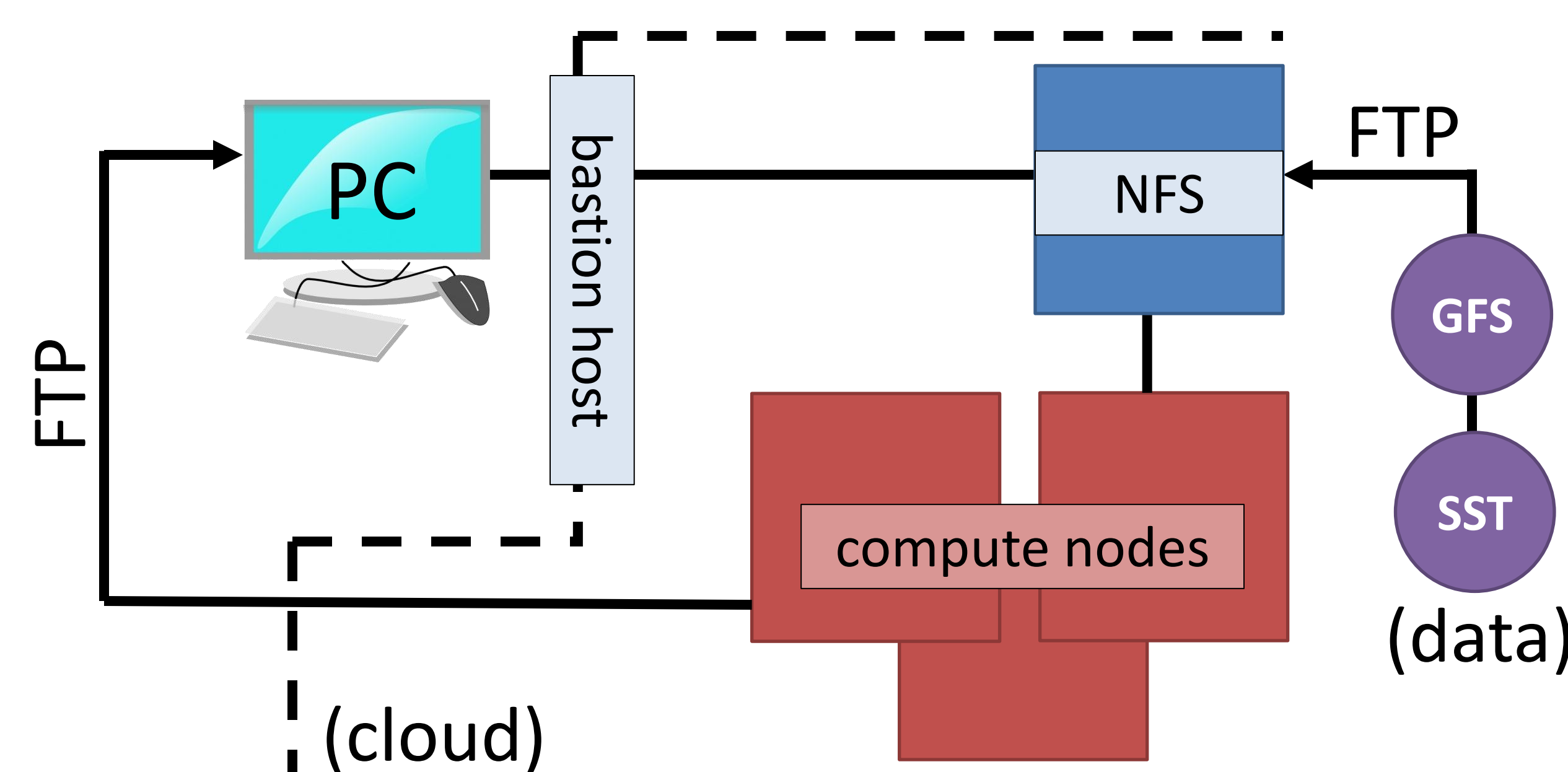


Figure 2. Overview of the cloud computing configuration used in generating the forecasts.

Example Output and Applications

- The domain configuration and resolution of this WRF-EMS setup are one of the highest resolution weather forecast models currently run over the region, improving upon the coverage provided by the NOAA North American Mesoscale (NAM) and GFS models.
- High resolution forecasts such as these can identify, with detail, many features associated with tropical cyclones and heavy precipitation that can be used to plan disaster mitigation and response activities.

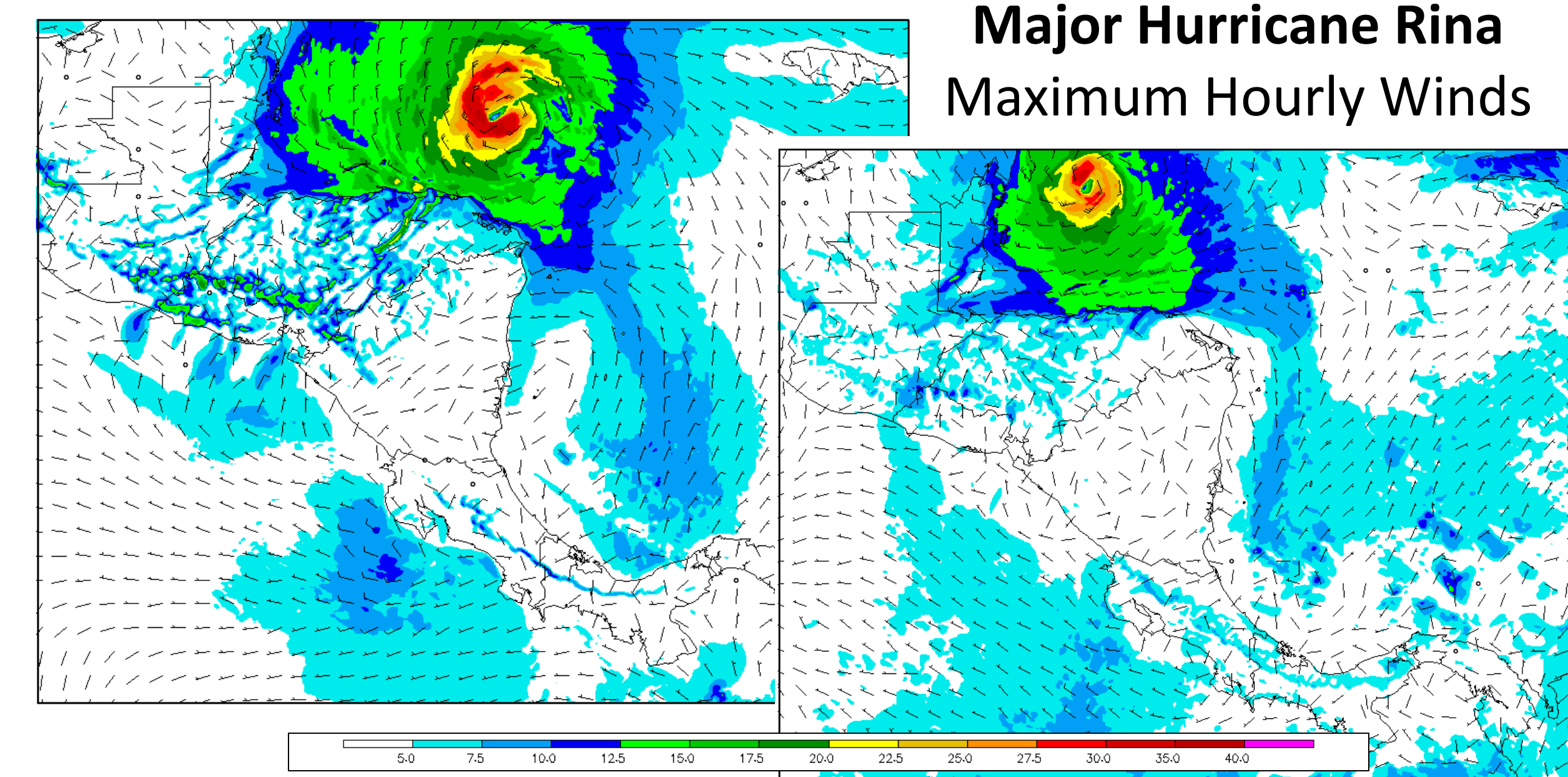


Figure 3. Maximum 10-m wind speed (m/s) in the preceding hour for Hurricane Rina in October 2011, as predicted by the WRF-EMS, cloud-based forecast model. In the upper left, maximum winds predicted for the previous hour ending at 12 UTC on October 25, and bottom right, for the hour ending at 18 UTC on October 26.

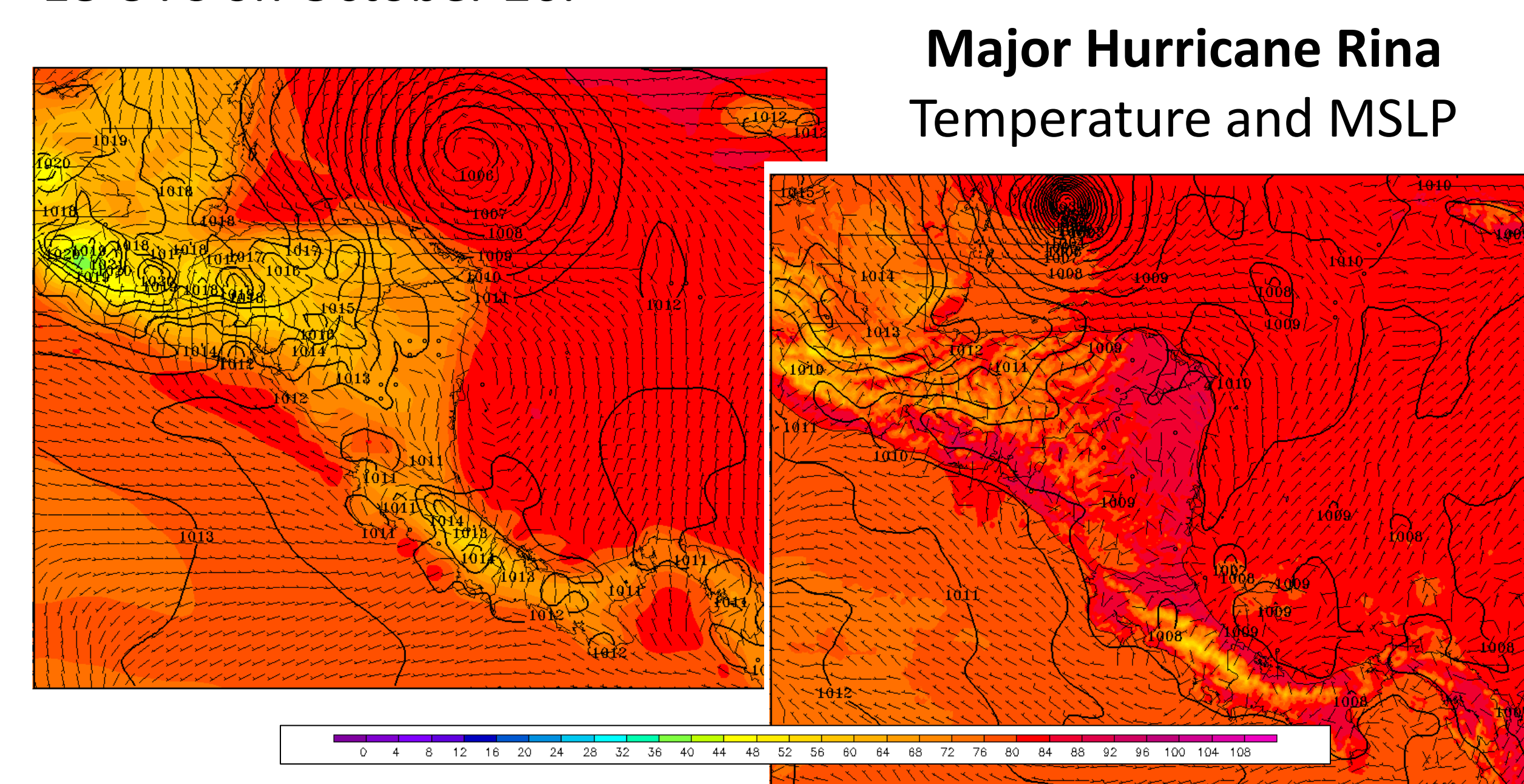


Figure 4. Temperature (F, color fill) and mean sea level pressure (contours) for Major Hurricane Rina, based upon forecasts valid at 12 UTC on October 25 (left) and 18 UTC on October 26 (right). The tightly spaced contours and reduced MSLP correspond to the storm's intensification and eye seen in the depiction of wind speeds shown in Figure 3.

Forecast Verification

- Along with qualitative comparisons between a given forecast and the actual event, quantitative verification between observations and forecasts is helpful to identify model errors and possible improvements.
- Verification was performed from May-October against available surface weather observations and precipitation estimates from the CMORPH product.
- Results suggest a cool bias in daily high temperatures and a potential bias towards overestimation of heavy precipitation, though precipitation estimation for these events in CMORPH may also contribute some errors.

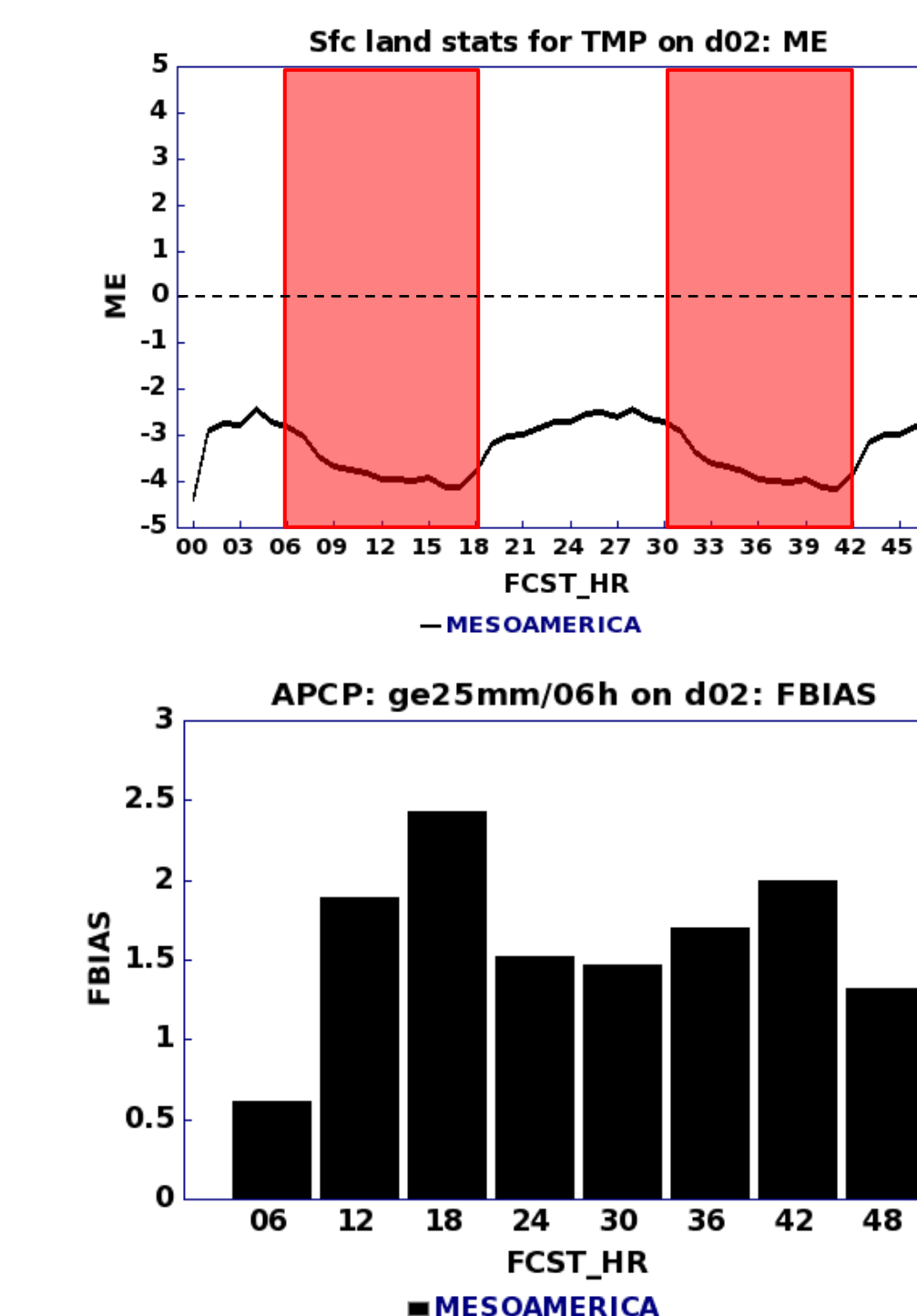


Figure 5. Example of verification of temperature (top) and precipitation (bottom). Negative temperature bias indicates the model is too cold during peak heating (red bars). Precipitation bias greater than zero suggests WRF predicts more precipitation than observed by CMORPH.

Future Work

- Additional modeling experiments will seek to reduce the bias in daily high temperature and further explore the possible bias in precipitation.
- These experiments will include different physics schemes and incorporation of land surface characteristics, such as vegetation and soil moisture provided by the NASA Land Information System and available satellite data.

Acknowledgements

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